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Memorandum

Date: June 19, 2007

From: Raed EL-Farhan

To: Robert Brent, VADEQ

Re: Rivanna River Benthic Impairment

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1. Purpose and Objective

The objective of this memorandum is to summarize the results of the stressor identification process for the benthic impaired segments of the Rivanna River. TMDL development for benthic impairments requires the identification of pollutant stressor(s) affecting the benthic macroinvertebrate community. Stressor identification for the biologically impaired segment of the Rivanna River was performed using the available environmental monitoring and watershed characterization data. This stressor identification follows the guidelines outlined in the EPA Stressor Identification Guidance (EPA, 2000).

2. Impaired Segments

There are currently two benthic impairments on the mainstem Rivanna River (**Figure 1**). The upstream impairment of the Rivanna River (VAV-H28R-01) begins at the confluence with the North and South Fork Rivanna Rivers and ends downstream at the confluence with Moores Creek. This segment was first included on Virginia's 1996 Section 303(d) List, and was subsequently included on Virginia's 303(d) Lists of Impaired Waters and Water Quality Assessment 305(b)/303(d) Integrated Reports based on biomonitoring results obtained between 1996 and 2005. According to the 2004 303 (d) fact sheets, the cause for the benthic macroinvertebrate impairment is believed to be related to non point source urban runoff. During the 2006 303 (d) assessment, DEQ concluded that the segment directly downstream of VAV-H28R-01 was also biologically impaired (DEQ, 2006). This segment (VAV-H29R-01) begins at the confluence with Moores Creek and ends downstream at an unnamed tributary just after the RWSA-Glenmore STP. Based on the 2006 303(d) list (DEQ, 2006), the source for the benthic macroinvertebrate impairment is unknown.

3. Watershed Characterization

The Rivanna River benthic impaired watershed covers approximately 332,530 acres in central Virginia and is located within the James River Basin. The watershed encompasses the City of Charlottesville and covers four counties: Albemarle, Greene, Nelson, and Orange. Of these eight counties, approximately 79% of the watershed lies within Albemarle County and 18% lies within Greene County (**Figure 2**).

Based on the National Land Cover (NLCD) 2001 Dataset, the dominant land uses in the benthic impaired watershed are forest (65%) and agriculture (22%) which account for of a total of nearly 87% of the land area in the watershed. In the watershed there are 38 permitted facilities. The permitted facilities present include 12 individual, 19 industrial stormwater, 3 concrete facilities, 1 car wash, 1 mining operation, and 1 chicken operation.

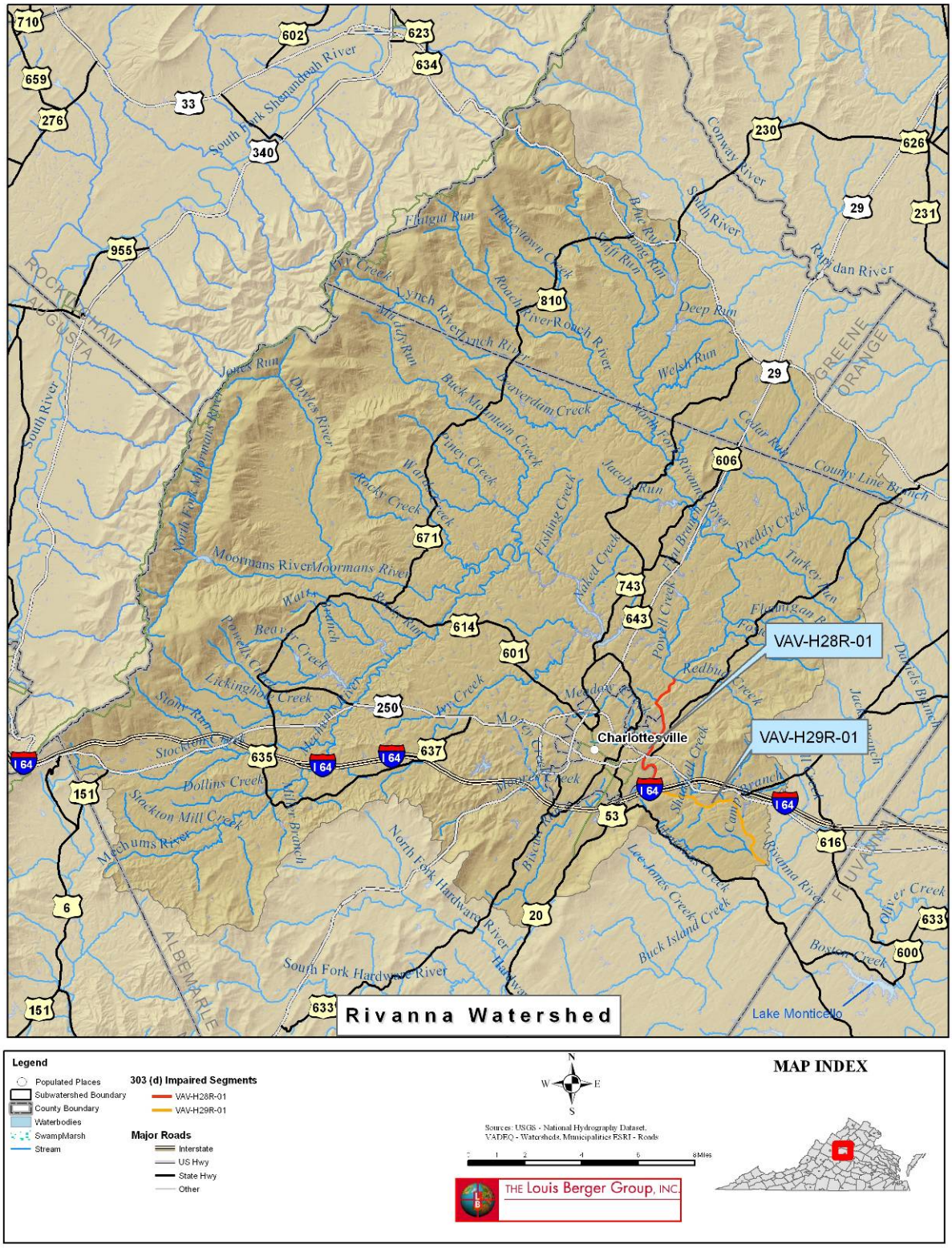

Figure 1: Rivanna River Benthic Impaired Segments

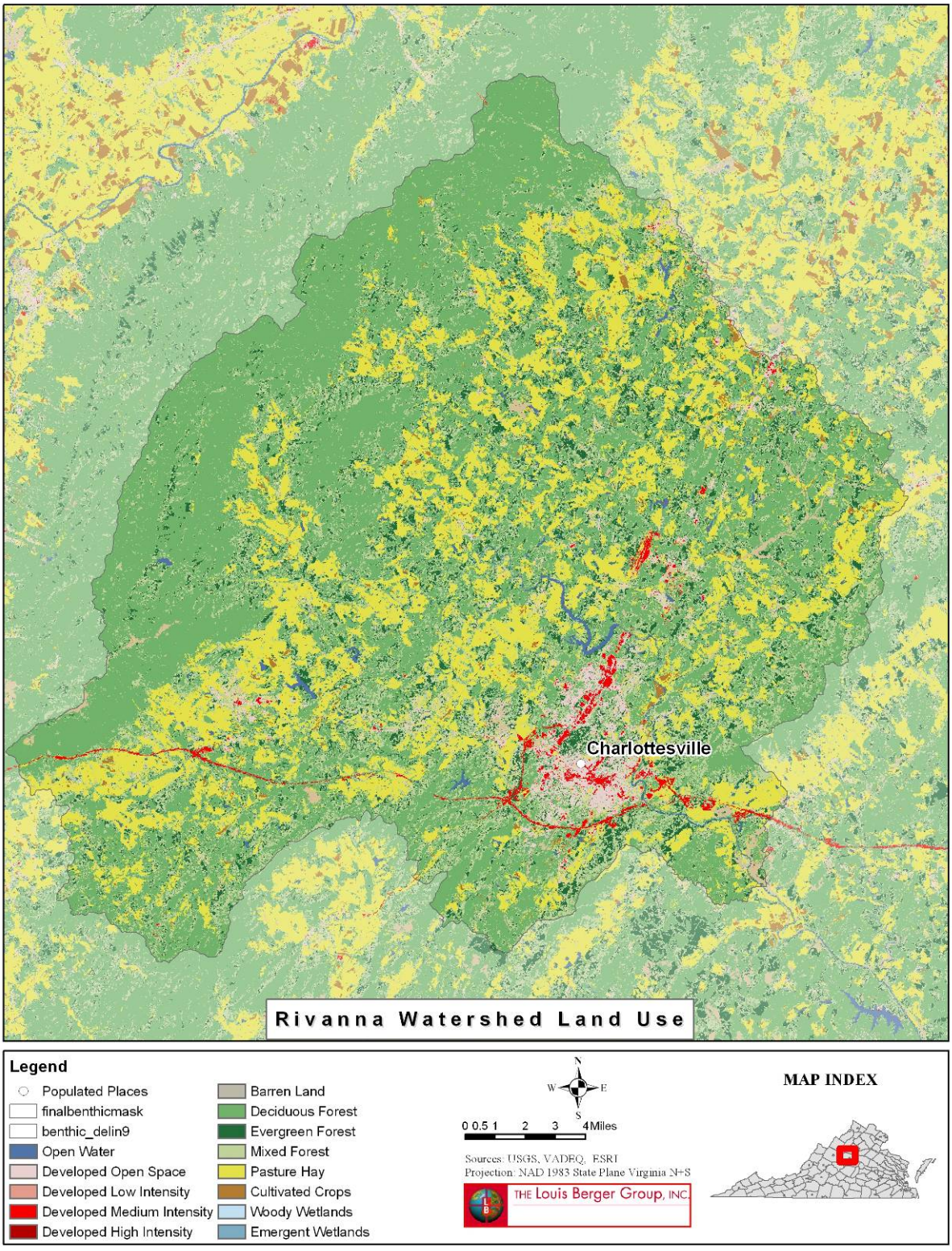

Figure 2: NLCD Land Use in the Rivanna River Benthic Impaired Watershed

4. Biological Monitoring Data

Biological monitoring data in the Rivanna River watershed was available from both DEQ and StreamWatch, a partnership composed of the Albemarle and Fluvanna counties, the Nature Conservancy, the Thomas Jefferson Soil and Water Conservation District, Rivanna Conservation Society, and the Rivanna Water and Sewer Authority. This memorandum will only present the benthic data collected along the Rivanna River benthic impaired segments.

4.1 VA DEQ Benthic Macroinvertebrate Sampling

VA DEQ collected benthic macroinvertebrate data at monitoring stations 2-RVN035.67 and 2-RVN033.65 located in the benthic impaired segment VAV-H29R-01 in the spring and fall of 2002 and 2005. Three benthic macroinvertebrate indexes have been used by VA DEQ to assess the biological condition of the stream's benthic invertebrate communities. These indexes include the EPA Rapid Bioassessment Protocols (RBPII), the Stream Condition Index (SCI), and the Macroinvertebrate Aggregated Index for Streams (MAIS).

Modified Rapid Bioassessment Protocol (RBPII) Index

Virginia DEQ uses a modified version of the EPA RBPII to assess the biological condition of the stream's benthic invertebrate communities. Candidate RBPII metrics, as specified in EPA's Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers, Second Edition (Barbour et al., 1999), are presented in **Table 1.** The modified version of the EPA RBPII follows a paired reference approach using reference stations located in the same ecoregion. The paired reference approach uses eight standard metrics to compare monitored and reference sites. These metrics are categorized in taxa richness, composition, and tolerance/intolerance measures, feeding measures, and other measures (**Table 1**).

Table 1: Candidate RBPII Metrics Specified in Barbour et al. (2002)

Category	Metric	Definition	Response to Disturbance
Richness Measures	Total No. Taxa	Measures overall variety of invertebrate assemblage	Decrease
	No. EPT Taxa	Number of Ephemeroptera, Plecoptera, and Trichoptera taxa	Decrease
	No. Ephemeroptera Taxa	Number of mayfly taxa	Decrease
	No. Plecoptera Taxa	Number of stonefly taxa	Decrease
	No. Trichoptera Taxa	Number of caddisfly taxa	Decrease
Composition Measures	% EPT	Percent of the composite of mayfly, stonefly, and caddisfly larvae	Decrease
	% Ephemeroptera	Percent of mayfly nymphs	Decrease
Tolerance/ Intolerance Measures	No. Intolerant Taxa	Taxa richness of organisms considered to be sensitive to perturbation	Decrease
	% Tolerant Organisms	Percent of the macrobenthos considered to be tolerant of various types of perturbation	Increase
	% Dominant Taxon	Measures dominance of the most abundant taxon. Can be calculated as dominant 2, 3, 4, or 5 taxa	Increase
Feeding Measures	% Filterers	Percent of the macrobenthos that filter FPOM from water column or sediment	Variable
	% Grazers and Scrapers	Percent of macrobenthos that scrape or graze upon periphyton	Decrease
Other Measures	Hilsenhoff Biotic Index	Uses tolerance values to weight abundance in an estimate of overall pollution	Increase

RBPII assessment ratings for the biomonitoring surveys conducted at stations along the biologically impaired listed segment VAV-H29R-01 of the Rivanna River are presented in **Table 2**. DEQ field data sheets and bioassessment forms completed for each biological assessment conducted on Rivanna River contained the following information:

- Assessment ratings for each station for each survey event
- The numbers and types of macroinvertebrates present at each station
- Habitat assessment scores taken during each survey
- Field water quality data collected as part of each survey

Based on the VA DEQ RBPII assessment ratings during the sampling periods of 2002 and 2005, the benthic community was listed as moderately impaired at each station during the spring and slightly impaired in the fall (**Table 2**). Also, samples at these two stations indicated that the total number of taxa were relatively low for all samples. The dominance of a few species as well as a lack of species that live within the crevices of rocks indicated that sediment may be impacting the macroinvertebrate community. The ratio of scraping to filtering collectors was greater in the fall samples at both sites. The abundance of scrapers tends to increase with increased diatom abundance and decrease as algae and mosses increase, while the abundance of filters has the opposite response. The composition of the benthic species shows that in the majority of samples, the dominant species was hydrosychidae, a filtering species commonly called netspinners, which are typically tolerant to pollution and can become abundant in streams that are subjected to moderate levels of organic wastes or nutrients. Organic pollution puts more particles in suspension and netspinners catch these particles using a mesh net. The observation that netspinners compose the majority of these samples indicates that the stream is potentially experiencing organic and nutrient enrichment (Voshell, 2002).

Table 2: RBPII Assessment Ratings for Rivanna River Biomonitoring Surveys

Station ID	**2-RVN033.65**		**2-RVN035.67**	
Location	Old Rt. 729 bridge site		0.4 miles upstream of Barn Branch	
Collection Date	5/23/2005	11/1/2005	5/23/2002	10/16/2002
Total Number of Taxa	11	15	12	16
HBI Score	5	5	6	6
SC/FC Ratio	0	1	0	1
EPT/Chir Abundance	2	9	2	3
%1Dominant	32	44	57	29
EPT Taxa	4	7	4	5
% Shredders	1	8	1	2
RBPII Score	46	71	35	54
Impairment Level	**Moderately Impaired**	**Slightly Impaired**	**Moderately Impaired**	**Slightly Impaired**

Stream Condition Index (SCI)

The SCI is a regionally-calibrated index currently being developed and revised by VA DEQ. This index uses eight metrics to determine the overall stream condition. The metrics used in the calculation of an SCI score are similar to the metrics used in RBPII assessments. However, unlike RBPII, the reference condition of the SCI is based on an aggregate of reference sites within the region, rather than a single paired reference site. Therefore, SCI scores provide a measure of stream biological integrity on a regional basis. An impairment cutoff score of 60.0 has been proposed for assessing results obtained with the SCI in the Rivanna watershed. Streams that score greater than 60.0 are considered to be non-impaired, whereas streams that score less than 60.0 are considered impaired. The eight metrics used to develop this index are shown in **Table 3**.

Table 3: Metrics Used to Calculate the Virginia Stream Condition Index (SCI)

Candidate Metrics (by categories)	Expected Response to Disturbance	Definition of Metric
Taxonomic Richness		
Total Taxa	Decrease	Total number of taxa observed
EPT Taxa	Decrease	Total number of pollution sensitive Ephemeroptera, Plecoptera, and Trichoptera taxa observed
Taxonomic Composition		
% EPT Less Hydropsychidae	Decrease	% EPT taxa in samples, subtracting pollution-tolerant Hydropsychidae
% Ephemeroptera	Decrease	% Ephemeroptera taxa present in sample
% Chironomidae	Increase	% pollution-tolerant Chironomidae present
Balance/Diversity		
% Top 2 Dominant	Increase	% dominance of the 2 most abundant taxa
Tolerance		
HBI (Family level)	Increase	Hilsenhoff Biotic Index
Trophic		
% Scrapers	Decrease	% of scraper functional feeding group

As shown in **Table 4**, the biological assessments conducted along the Rivanna River impaired segment were all below the impairment cut off score. Therefore, all samples collected at these two stations were considered impaired. The specific metrics and the macroinvertebrate community structure indicated that nutrient and organic pollution as well as riffle emdeddedness may be impacting the macroinvertebrate community.

Table 4: SCI Assessment Ratings for Rivanna River Biomonitoring Surveys

Season	2-RVN033.65	2-RVN035.67
Spring 2002	-	33.03
Fall 2002	-	53.94
Spring 2005	44.66	-
Fall 2005	56.92	-
Average	**50.79**	**43.48**

Macroinvertebrate Aggregated Index for Streams (MAIS)
DEQ also used the MAIS index to determine the health of the benthic community. This index uses similar rankings to the SCI and RBPII methods. The MAIS was developed by Voshell et. al (1997) based on benthic macroinvertebrate data from streams in the Mid-Atlantic Highlands of Maryland (51 sites), Pennsylvania (53 sites), Virginia (126 sites) and West Virginia (200 sites). The MAIS summarizes the values of 10 metrics of which the majority are previously described in **Tables 1** and **3**. These metrics are the following:

- Ephemeroptera Richness,
- EPT Richness
- Intolerant Taxa Richness
- % Ephemeroptera
- % EPT
- % 5 Dominant Taxa
- Simpson Diversity
- HBI (Hilsenhof Biotic Index)
- % Scrapers
- % Haptobenthos

Values for the individual metrics are transformed into a score of 0, 1 and 2, and then combined into a MAIS score out of a possible 20. MAIS scores calculated at the two benthic impaired stations indicated that there is a moderate benthic impairment (**Table 5**).

Table 5: MAIS Scores at Rivanna River Stations

Station ID	Season Sampled	MAIS Score	Assessment
2-RVN033.65	Spring 2002	10	Moderate Impairment
	Fall 2002	12	Moderate Impairment
2-RVN035.67	Spring 2005	7	Moderate Impairment
	Fall 2005	11	Moderate Impairment

4.2 Stream Watch Benthic Macroinvertebrate Sampling

StreamWatch has been monitoring the benthic community of the Rivanna River watershed since 2002. This community monitoring group used both VA DEQ SCI method and the Save our Streams (SOS) method to assess the biological condition of the stream's benthic invertebrate communities. StreamWatch has conducted sampling at numerous stations within the watershed and at three stations located directly on the benthic impaired segment VAV-H29R-01. The following summary only includes data collected at stations (RVN01, RVN06, RNV11) along the benthic impaired segments (**Figure 3**).

As shown in **Table 6**, the ecological conditions for 17 out of 32 samples taken were considered to be unacceptable. The percent of tolerant insects in these samples were consistently high (average: 40%) while the percentage of sample comprised of netspinners varied between 0.1 and 59%. At the upstream station, RVN11, the majority of samples were considered to be ecological acceptable and several samples were above the SCI cutoff score. The one sample conducted at Station RVN06 indicated that the benthic community was in an unacceptable condition. The percent of netspinners collected at this station was higher than samples collected downstream at RVN01. Since an impairment cutoff score of 60.0 has been proposed for assessing results obtained with the SCI in the Rivanna watershed, streams that score greater than 60.0 are considered to be non-impaired, whereas streams that score less than 60.0 are considered impaired. Therefore, based on this criterion, all samples except 3 collected at station RVN01 were below the cutoff score.

Table 6: StreamWatch Results at the Stations along the Benthic Impaired Segments		
Station	**Season**	**SCI Scores***
RVN01-Rivanna @ Milton	Winter2002	NA
	Spring 2003	NA
	Fall 2003	NA
	Winter 2004	47.0
	Spring 2004	38.1
	Summer 2004	NA
	Fall 2004	44.6
	Winter 2005	52.7
	Spring 2005	62.8
	Summer 2005	56.8
	Fall 2005	60.0
	Winter 2006	51.1
	Spring 2006 (March)	41.4
	Spring 2006 (May)	60.3
	Summer 2006	52.8
	Fall 2006	50.0
RVN06-Rivanna @ Monticello	Fall 2003	NA
RVN11- Rivanna # Darden Towne	Winter 2002	NA
	Spring 2003	NA
	Fall 2003	NA
	Fall 2003	NA
	Winter 2004	38.4
	Spring 2004	49.6
	Fall 2004	55.3
	Winter 2005	53.3
	Spring 2005	55.9
	Summer 2005	62.8
	Fall 2005	63.9
	Winter 2006	38.5
	Spring 2006	72.5
	Summer 2006	57.8
	Fall 2006	69.9

* NA: Indicates that a SCI score was not able to be calculated

5. Habitat Condition Assessments

Habitat condition assessments of the benthic impaired segment were conducted by VA DEQ and Stream Watch. However, the instream habitat condition assessment by Stream Watch was not available for stations along the impaired segments. As a result, only the habitat condition assessment by VA DEQ is presented for this analysis.

DEQ Habitat Condition Assessments

A suite of habitat variables were visually inspected at monitoring stations 2-RVN035.67 and 2-RVN033.65 in the spring and fall of 2002 and 2005 as part of the biological assessments conducted on the Rivanna River. Habitat parameters that were examined include channel alteration, sediment deposition, substrate embeddedness, riffle frequency, channel flow and velocity, stream bank stability and vegetation, and riparian zone vegetation. Each parameter was assigned a score from 0 to 20, with 20

indicating optimal conditions, and 0 indicating very poor conditions. Habitat assessment scores for the Rivanna River biomonitoring and relevant reference stations are presented in **Table 7**. Overall habitat assessment scores were generally low for several parameters at these stations. Specifically, scores for habitat metrics such as embeddedness and sediment deposition were considered to be suboptimal. Embeddedness is a measure of how much sediment is occupying the spaces between the substrate of the streambed. The more space available between cobbles and rocks, the more habitats allowed for different species of macroinvertebrates. Sediment deposition corresponds with embeddedness and can be visible in a stream in the form of sand bars. This buildup of sediment in the stream bed can drastically change the composition of macroinvertebrate habitats and therefore can be a stressor for the benthic community.

Table 7: DEQ Habitat Condition Assessments

Station ID	**2-RVN033.65**	**2-RVN033.65**	**2-RVN035.67**	**2-RVN035.67**
Collection Date	5/23/2005	11/1/2005	5/23/2002	10/16/2002
Total Habitat Score	159	139	155	163
Channel Alteration	18	18	20	19
Bank Stability	16	12	18	18
Bank Vegetation	18	18	18	20
Embeddedness*	**12**	**6**	**-**	**13**
Channel Flow	14	15	17	19
Riffles	18	18	16	14
Riparian Zone	18	14	20	20
Sediment Deposition*	**12**	**10**	**12**	**11**
Substrate	15	12	17	12
Velocity Regime	18	16	17	17

*These habitat parameters were considered to be suboptimal for all samples.

6. Toxicity Testing

Toxicity testing was performed on water samples collected on the Rivanna River by DEQ at stations 2-RRN002.19, located on the North Fork Rivanna River, and 2-RVN033.65, located on the mainstem the benthic impaired segment VAV-H29R-01 on October 24, 26, and 28 2005. The EPA Region 3 laboratory in Wheeling, West Virginia performed chronic toxicity testing on samples using fathead minnows and *Ceriodaphnia dubia*, also known as water fleas, as test organisms. Results indicated Ceriodaphnia mortality and reproduction in the Rivanna River water samples were not statistically different than mortality and reproduction in the control samples, thus indicating that there were no toxic water column effects to Ceriodaphnia in the Rivanna River samples.

Toxic effects were noted on fathead minnows in the Rivanna River water samples. Fathead minnow survival rates in samples collected at station 2-RNV002.19 and at station 2-RNV033.65 were statistically different from the laboratory control. The EPA Region 3 laboratory in Wheeling indicated that this result "was probably biologically significant", and that it was necessary to compare the observed toxicity testing results with other water quality data collected at this site to determine the presence of toxicity.

Additional samples were collected for toxicity testing by DEQ at station 2-RVN033.65 on May 15, 17, and 19, 2006. These samples did not have any effect on Ceriodaphnia mortality and reproduction. However, results from these samples did indicate that there was an adverse effect on both the fathead minnow survival and biomass. It should also be noted that during both sampling periods of the toxicity tests, there were major storm events based on readings at USGS gage at Palmyra. These storm events

would have provided more runoff from the land area and potentially increased the toxic effects in the river that may not be present normally. Therefore, based on these tests, there is a possible toxic effect in the Rivanna River.

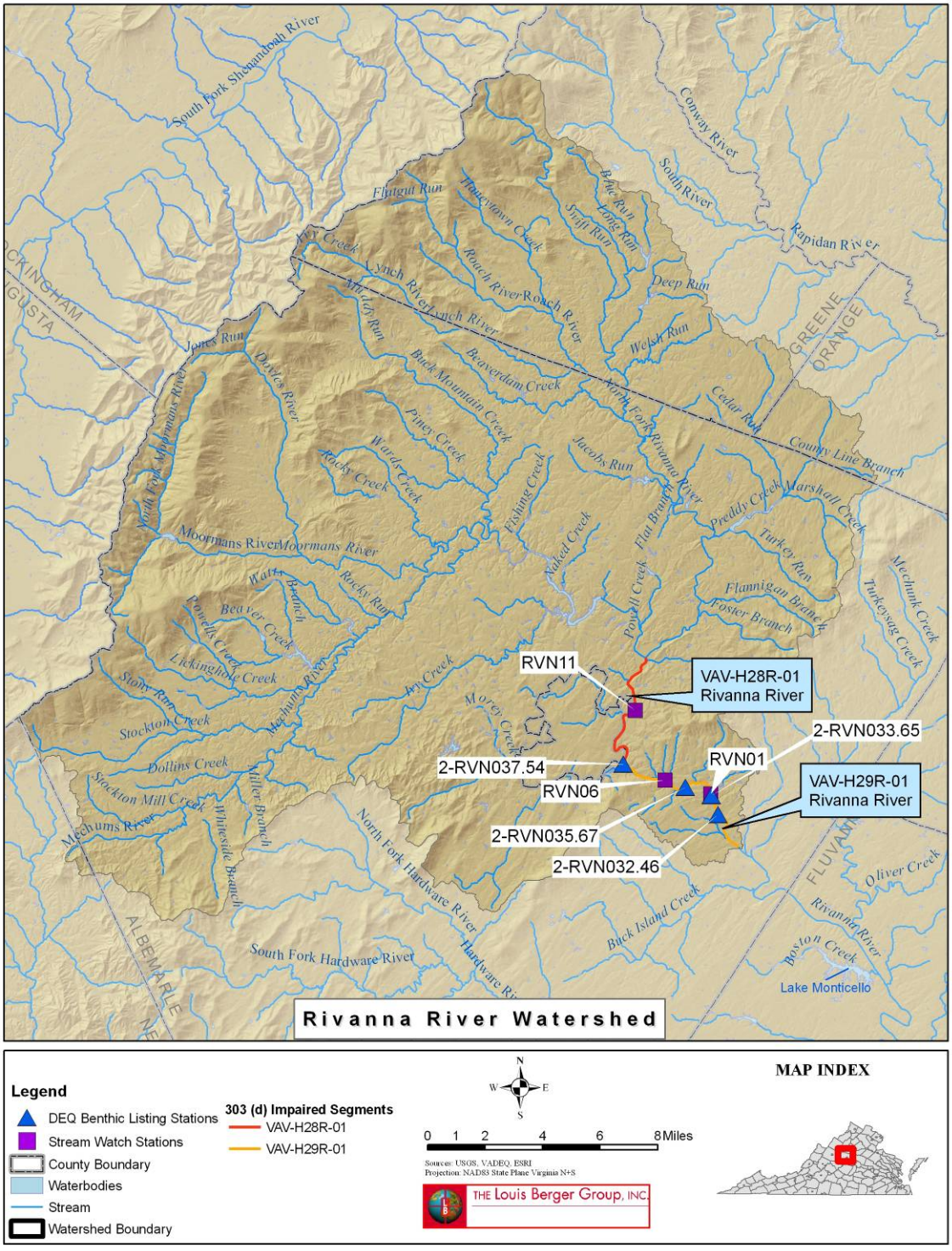

Figure 3: Benthic and Water Quality Stations on the Rivanna River Impaired Segment

7. Water Quality Data

Ambient water quality monitoring has been conducted by VA DEQ along the impaired segments of the Rivanna River since 1968. For the purposes of this study, only data collected since 1996 was analyzed and compared to VA DEQ water quality standards to correspond with the impairment listing date (DEQ, 2006). During this sampling period, VA DEQ collected instream water quality and river sediment samples. The instream water quality measurements included general parameters (temperature, DO, pH, and spec. conductivity) and chemical parameters (nutrients, solids, metals, and organics). The river sediment measurements included heavy metals and organic contaminants and were only monitored on July 1996 at station 2-RVN037.54 and on May 2002 at station 2-RVN032.46. The instream heavy metals data collected include aluminum, antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc. These metals were all below the acute or chronic dissolved freshwater criteria specified in Virginia's aquatic life use standards. All of the sediment and organic samples were below the detection limit.

Of the four monitoring stations located on the impaired segments, only two stations, 2-RVN037.54 and 2-RVN033.65, were used for the analysis of the instream water quality data, since the remaining two water quality stations (2-RVN032.46, and 2-RVN035.67) were only sampled once. **Table 8** shows a summary of selected instream data collected at stations 2-RVN037.54 and 2-RVN033.65.

Table 8: Summary of Instream Water Quality Data Collected at 2-RVN037.54 and 2-RVN033.65 between 1996 and 2006

Station ID		**2-RVN037.54**				**2-RVN033.65**			
Parameter	**Units**	**No of Samples**	**Min**	**Max**	**Avg**	**No of Samples**	**Min**	**Max**	**Avg**
Temperature	°C	48	0.20	27.90	15.37	89	1.20	29.50	13.80
DO	mg/L	48	6.20	15.00	10.04	89	5.50	17.40	11.00
Field pH	SU	48	5.90	8.20	7.27	89	6.30	8.90	7.45
Spec. Conductance	µmhos/cm	10	56.40	89.30	69.33	14	58.30	190.00	95.47
Chloride	mg/L	18	3.90	10.25	5.91	65	4.50	41.80	9.21
Turbidity	FTU	21	1.80	28.00	10.06	75	1.20	77.00	10.23
TSS[1]	mg/L	22	3.00	19.00	7.77	86	3.00	90.00	9.56
VSS[2]	mg/L	18	3.00	4.00	3.06	32	10.00	52.00	26.00
Total NH_3-N	mg/L	29	0.04	0.10	0.05	85	0.04	0.80	0.07
NO_2-N + NO_3-N	mg/L	29	0.11	0.86	0.33	87	0.00	6.27	1.11
TN[3]	mg/L	29	0.25	1.10	0.57	87	0.00	7.57	1.49
PO_4-P	mg/L	17	0.01	0.04	0.02	85	0.02	1.48	0.20
TP	mg/L	29	0.01	0.10	0.06	76	0.01	1.60	0.24
Chl*a*[4]	ug/L	-	-	-	-	10	0.50	4.17	1.58

[1] TSS = total suspended solids (total non-filterable residue)
[2] VSS = volatile suspended solids (total volatile residue)
[3] Combination of measured and computed (TN = TKN + NO3-N + NO2-N) values
[4] Phytoplankton

Based on the data summarized in **Table 8**, the majority of instream water quality parameters complied with VA DEQ water quality standards. The only water quality standard exceedances were for pH. The pH criteria was exceeded once at station 2-RVN037.54 in 1998. Also, the VSS (volatile suspended solids) increased significantly at the downstream station (2-RVN033.65). In addition, it should be noted

that nitrogen and phosphorus concentrations increased significantly in the benthic impaired segment VAV-H29R-01 at 2-RVN033.65 compared to VAV-H28R-01 at 2-RVN037.54. In fact, the ortho-phosphorus concentration at the downstream station located in the benthic impaired segment VAV-H29R-01 is ten times higher than the ortho-phosphorous concentration at the upstream station (2-RVN037.54). Also, the NO_x-N (NO_2-N + NO_3-N) values were more than three times higher than in the upstream station located in the benthic impaired segment VAV-H28R-01. This significant difference of nutrient levels in both impaired benthic segments is also mirrored in the average annual total phosphorus levels depicted in **Figure 4**.

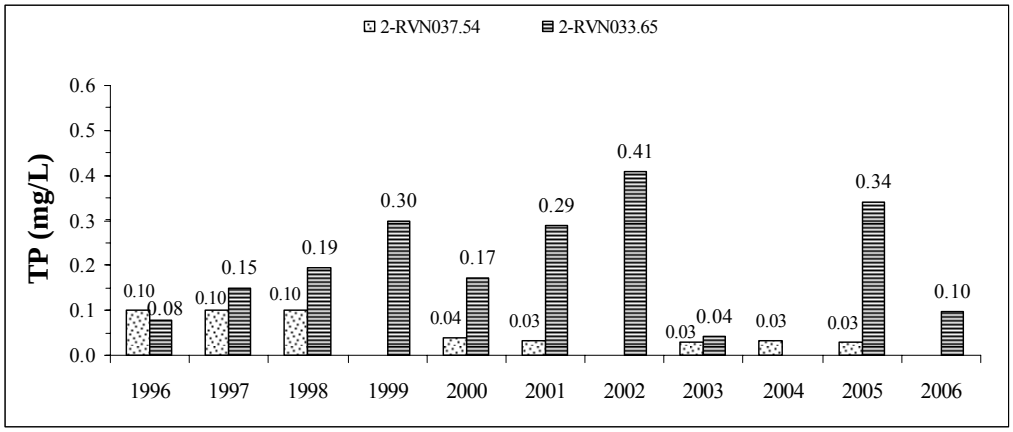

Figure 4: Average Yearly Total Phosphorus in the Rivanna River within Both Impaired Segments

Diurnal Dissolved Oxygen

VADEQ performed diurnal continuous DO monitoring in August 2006 at station 2-RVN033.65 on the Rivanna River. The objective of the continuous DO monitoring was to assess and identify any DO exceedances over a diurnal cycle. As shown in **Figure 5**, during these three days, there were no exceedances of the dissolved oxygen minimum (4 mg/L) or average standards (5 mg/L). Therefore, this daily DO fluctuation indicates that dissolved oxygen within the Rivanna River is probably not a stressor to the benthic community.

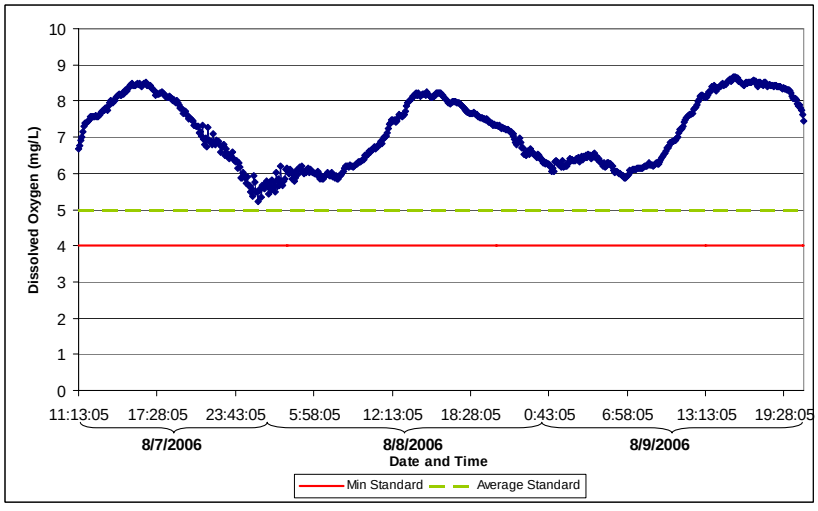

Figure 5: Diurnal Dissolved Oxygen in the Rivanna River

8. Stressor Identification Analysis

The identification of the most probable cause of biological impairment in the Rivanna River was based on evaluations of candidate stressors potentially impacting the river. The evaluation includes possible stressors such as dissolved oxygen, temperature, pH, metals, organic chemicals, nutrient, toxic compounds, and sediments. Each candidate stressor was evaluated based on available monitoring data, field observations, and the consideration of potential sources in the watershed. Furthermore, potential stressors were classified as:

Non-stressors: The stressors with data indicating normal conditions and without water quality standard violations, or without any apparent impact

Possible stressors: The stressors with data indicating possible links, however, with inconclusive data to show direct impact on the benthic community

Most probable stressors: The stressors with the conclusive data linking them to the poorer benthic community. **Table 9** summarizes the results of the analysis.

Table 9: Summary of Stressor Identification in the Rivanna River

Non-Stressors
Temperature and pH
Dissolved oxygen
Instream metals
Organic and metal contaminants in river sediments
South Fork Rivanna Reservoir Discharge
Possible Stressors
Phosphorus
Toxicity
Most Probable Stressors
Sediment/ Urban Runoff

8.1 Non-Stressors

Temperature and pH

Benthic invertebrates require a suitable range of temperature and pH conditions. High instream temperature values and either very high or very low pH values may result in a poor quality invertebrate assemblage comprised predominantly of tolerant organisms. Field measurements indicated that adequate temperature values were recorded on the biologically impaired segments. All recent pH measurements showed a suitable range for benthic invertebrates except for one occasion on September 1998 when pH was one tenth of a pH unit lower than the minimum pH standard. However, this violation is deemed to be not representative, since the violation was only slightly lower than the standard and occurred on one occasion. Therefore, temperature and pH do not appear to be adversely impacting benthic communities in the Rivanna River and are classified as non-stressors.

Dissolved Oxygen

Adequate dissolved oxygen (DO) levels are necessary for invertebrates and other aquatic organisms to survive in the benthic sediments of rivers or streams. Decreases in instream oxygen levels can result in oxygen depletion or anoxic sediments, which adversely impact the river's benthic community. The field dissolved oxygen samples and the diurnal monitoring samples both complied with the dissolved oxygen standards. Therefore, dissolved oxygen is considered to be not impacting the benthic community.

Heavy Metals in the Water Column and River Sediments

All available dissolved heavy metals data (aluminum, antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc) were below the detection limits. Consequently, heavy metals do not appear to be stressors affecting the benthic macroinvertebrates in the Rivanna River. In addition, all sediment samples collected were below the detection limit.

South Fork Rivanna Reservoir Discharge

The South Fork Rivanna Reservoir is located approximately 3.4 miles upstream of the benthic impaired segment. Stakeholders at the local steering committee meeting mentioned the possibility of water with low dissolved oxygen released from the bottom of the reservoir impacting the benthic health. Discharge from reservoirs can have a localized effect on the benthic community downstream of the impoundment due to reduced oxygen and limited upstream recruitment of macroinvertebrates.

The South Fork Rivanna Reservoir is considered to be a non-stressor on the Rivanna mainstem. The distance between the reservoir and the impaired reach is considered adequate for reaeration. The North Fork Rivanna River, which is unimpaired, would provide additional flow, oxygen, and macroinvertebrate recruitment before the Rivanna River mainstem impairment. In addition, the upstream end of the Rivanna River mainstem impaired reach typically had better benthic scores than the downstream portion (based on StreamWatch scores from Darden Towe and Milton stations). These scores would be expected to be lower if the South Fork Reservoir was a primary stressor on the mainstem Rivanna community.

8.2 Possible Stressors

Phosphorus

An abundance of instream phosphorus is considered to play a major role in the eutrophication of stream systems. Based on VA DEQ benthic macroinvertebrate sampling conducted in the impaired segment VAV-H29R-01 at VA DEQ stations 2-RVN035.67, 2-RVN033.65, and 2-RVN032.46, the majority of samples were composed of macroinvertebrates typically tolerant to pollution from organic wastes or nutrients. The diurnal dissolved oxygen fluctuation is indicative of a healthy system with no dissolved oxygen standard violations and the instream total phosphorus loads in the downstream impaired segment may be a possible stressor affecting benthic macroinvertebrates. The Moores Creek STP is considered to be the primary cause of the increase of phosphorus between the two ambient monitoring stations. By 2010, this plant will be upgraded to remove nutrients to comply with the new state regulations on nitrogen and phosphorus loadings to the Chesapeake Bay.

These nutrient levels and the dissolved oxygen levels show the stream may be prone to eutrophic conditions in the future. Nutrient enrichment could impact benthic health through changing species composition and community structure prior to observing decreased dissolved oxygen levels. For this reason, phosphorous is considered a possible stressor.

Toxicity

Acute and chronic toxicity testing was conducted along the impaired segment. These tests showed that there was not a toxic effect of the *Ceriodaphnia dubia*, also known as water fleas, for both surveys. However, based on results from both toxicity tests, there was a biological effect on fathead minnow survival and biomass. It should be noted that these toxicity tests do not provide information on the source

of the toxics that may be affecting the fish community. It should be noted that during both sampling periods of the toxicity tests, there were major storm events. These storm events would have provided more runoff from the land area and potentially increased the toxic effects in the river that may not be present normally. Therefore, based on these tests, there is a possible toxic effect to the biological community in the Rivanna River.

8.3 Most Probable Stressors

Sedimentation and Urban Runoff

Sedimentation and urban runoff have been identified as most probable stressor in the Rivanna River benthic impaired segments based on the composition of the benthic community, and benthic habitat data from the impaired stations. In particular, embeddedness and sediment deposition habitat scores at the impaired stations were suboptimal. Although riparian and bank stability scores were considered to be within an acceptable range in the impaired segments, land use and riparian zone data in the upper portion of the watershed is considered suboptimal. Erosion and runoff contributing from the upstream areas would contribute to the embeddedness and sediment deposition observed at these stations.

Although the majority of the watershed is forested and agricultural land, the area upstream and surrounding the portion of the Rivanna River benthic impairment is within the City of Charlottesville. The impervious surfaces within the urban areas will increase the speed of runoff which can erode banks, scour stream beds, and deliver toxic chemicals. Also, in the upper portion of the watershed, studies have shown that there is a high level of sedimentation related to stream bank instability. StreamWatch, The Nature Conservancy, The Thomas Jefferson Soil and Water Conservation District, Rivanna Conservation Society, and the Rivanna Water and Sewer Authority have conducted stream surveys in the area. One survey conducted in 2002, which covered 20 miles in Albemarle County, estimated that 15% of banks are eroded and a 2006 survey found that 24%-30% of banks near monitoring stations were actively eroding (StreamWatch, 2006).

In addition, The Nature Conservancy's Rivanna Watershed Conservation Area Plan (2004) listed historical land clearing and conversion of forests to agriculture as the largest threat to the system. Although sedimentation is regarded as the primary stressor, it is unclear if the primary source of sediment loading is from stream banks or runoff. According to Bower (2003), sediment loads have varied over the decades although not measurably between 1980 and 1990 which may indicate that human influence may have not increased or decreased the rate of sedimentation. Also, sediment loads may have varied due to large storm events such as hurricanes.

Urban runoff can contribute sediment toxic chemicals in the water column and nutrients from land areas to the stream. The toxicity studies indicated that there was a toxic effect on fat head minnows. However, the source of the toxicity has not been identified. These observations indicate that urban runoff may be affecting the benthic community.

9. Stressor Identification Summary

The data and analysis presented in this memorandum indicate that temperature, pH, dissolved oxygen, instream metals, organic and inorganic contaminants in the sediments, and impacts from the South Fork Rivanna Reservoir are not effecting the invertebrate community in the benthic impaired segment, and therefore are not stressors contributing to the benthic impairment. The data analysis also shows that phosphorous as well as toxicity may contribute to the benthic impairment in Rivanna River. Consequently, these parameters are classified as possible stressors. The most possible stressors for the Rivanna River watershed are considered to be sedimentation and urban runoff. In fact, several of the probable stressors identified such as nutrients and toxicity may be the result of urban runoff.

10. References:

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling (1999). *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish.* Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Bower, P. Stephen (2003). *South Fork Rivanna Reservoir and Watershed Reflecting of 36 Years, Anticipating 50 Years.* Prepared for the Rivanna Water and Sewer Authority, Albemarle County Service Authority, City of Charlottesville, VA, and County of Albemarle, VA.

EPA (2000). *Stressor Identification Guidance Document*. U.S. Environmental Protection Agency, Office of Research and Development, EPA 822-B-00-025, Washington, DC.

VA DEQ (2004). *Water Quality Assessment 305(b)/303(d) Integrated Report.* Virginia Department of Environmental Quality, Richmond, Virginia.

VA DEQ (2006). *Water Quality Assessment 305(b)/303(d) Integrated Report.* Virginia Department of Environmental Quality, Richmond, Virginia.

StreamWatch (2006). *Living in Our Watershed, Correlates of Biological Condition in streams and Rivers of the Rivanna Basin- Winter 2003/04 though Fall 2005*. Stream Watch Program.

Voshell et. al (1997). Voshell, J. R., E. P. Smith, S. K. Evans, and M. Hudy. 1997. Effective and scientifically sound bioassessments: Opinions and corroboration from academe. Hum. Ecol. Risk Assess. 3: 941-954.

The Nature Conservancy (2004). *Rivanna Watershed Conservation Area Plan*. Charlottesville, Virginia.

Voshell, J. (2002). *A Guide to Common Freshwater Invertebrates of North America*. The McDonald and Woodward Publishing Company, Blacksburg, Virginia.